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FINAL TECHNICAL REPORT FOR NASA GRANT #NAGW-487

"Archean sedimentation and tectonics in South Africa"

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Final Report for NASA Research Grant Award #NAGW-487
"ARCHEAN SEDIMENTATION AND TECTONICS IN SOUTHERN AFRICA"

W.S.P. Kidd

Project Director

This grant funded travel to and from, and three weeks of field work in two areas of Southern Africa, both of which expose rocks from the early history of the earth, formed prior to 2.5 Ga ago. Three days were spent examining sequences in the Barberton Mountain Land greenstone belt, mainly in order to familiarize myself with rocks of this age that are in a relatively not very metamorphosed and structurally disturbed state, at least in comparison to the rocks in the second area, the Limpopo belt. A second aim in the reconnaissance of the Barberton rocks was to consult with geologists actively working in the area in order to see if there were topics and/or areas within the belt that warranted further investigation and that could lead to a larger-scale proposal to this program. A particular interest concerned the nature of the sedimentary rocks high in the sequence, their tectonic implications and their bearing on the present large-scale structural condition of the belt. I found that while there are some relatively poorly investigated parts of the belt, these are the structurally more complex areas that contain for the most part strongly deformed rocks and that are consequently much less easy to interpret. In the most promising areas, detailed mapping by various groups is in progress and, despite the fact that only preliminary reports have as yet been published, it would not be useful to duplicate their efforts. Despite this conclusion, the brief examination of the Barberton belt was most valuable for making comparisons with the Limpopo belt rocks and for developing and modifying some general ideas on Archean tectonics.

The remaining 2-1/2 weeks field time was spent examining rocks of the Limpopo belt, as a collaborative effort with Dr. K. Eriksson of Virginia Polytechnic Institute. A major purpose was to assess, if possible, whether there was evidence for a significant

component of shallow-water-deposited sedimentary rocks in the parent materials of the Limpopo belt, as seemed possible from reconnaissance reports. Because the rocks are now so highly deformed and metamorphosed, it was found that there are no consistently developed signs of shallow-water sedimentation in the form of the sedimentary structures (and sequences of these) used in little-altered sedimentary sequences as one of the main ways to identify shallow deposits. However, the substantial thicknesses and exceptional compositional purity that we observed in many occurrences of two kinds of rock, namely quartzites and marbles (and that are found widely distributed in the Limpopo belt) are a very strong indication that they are deposits of shallow water environments. The contrast with the largely volcanic sequence seen in the Barberton and many other greenstone belts is extreme, as is the contrast with the limited quantities and generally impure types of sediments that do occur in the greenstone belts. The major implication of our observations is that the existence of these sediments implies a continental substrate of significant size. First, a large transport distance is required in order to obtain substantial quantities of such pure quartzites from the original quartz-bearing source. Secondly, thick sequences of pure carbonates require a slowly subsiding substrate, which could be an oceanic volcanic accumulation, an inactive island arc or more evolved continental material. The existence of quartzofeldspathic gneissic basement locally in the Limpopo belt, and the regional relationships to the Kaapvaal craton where island arc and oceanic suites appear to have been assembled by compressional tectonic activity (i.e. collision) before about 3.3 Ga, suggest that the continental basement is the right answer for the Limpopo belt. Extreme structural complexity within the Limpopo belt prevents a reconstruction of the original facies and/or superpositional relationships between the quartzites, marbles, and other, largely pelitic metasediments that lie between them. A major difference between these rocks and those of similar aspect in younger orogenic belts is the volume of largely mafic (presumed intrusive) material intimately interlayered with them. Again, because of the structural complexity and extremely high strain, it is impossible to be certain about the origin

and tectonic significance of these rocks, but they may reflect one secular change in tectonic style from the Archean to younger times. It is very clear that the Limpopo central belt is unique among larger Archean terranes in that none of the others that are well described contain similar quantities of shallow sediments.

One other aspect of the geology was examined: the nature of a large high strain zone on the southern margin of the central Limpopo belt. This zone had been reported as having offsets of thrust, normal and strike-slip sense. Examination of the mylonites in the field leaves no doubt that they represent largely strike-slip displacement since they have a subvertical foliation and a subhorizontal stretching lineation. Because of the substantial width of this shear zone (~ 20 km) the total displacement on it could be extremely large. Samples taken for determining the sense of shear are in process of being examined. Preliminary results from these and field observations suggest right-lateral displacement. This zone, and two others like it (that were not examined) are late structures in the tectonic development of the Limpopo belt and are very similar in style and timing to large faults seen in geologically younger zones of continental collision. The general geology of the Limpopo belt is consistent with this notion, although it is likely that the large-scale assemblages have been much modified or reduced by the late strike-slip phase. In particular, no easily identified suture zone can be demonstrated; it is however entirely possible that at the erosional depth preserved the suture is cryptic.

Other funding has enabled presentation and publication of some results from the field work. The abstract of a paper given at the Lunar and Planetary Institute's workshop on the Early Earth in April 1984 is attached. Also attached is a copy of the manuscript of a paper written in collaboration with K. Burke and T. Kusky, submitted for publication in *Tectonophysics* (in review). One section in this manuscript draws on material from the field study funded by this grant. Additionally, it is likely that K. Eriksson and myself will in the near future prepare a short manuscript comparing the Limpopo belt metasediments with those from other Archean belts and commenting on their tectonic implications.